Report to Congress:

Energy Policy Act of 2005 • Section 353(e)
Gas Hydrate Production Incentive—Review

Bringing Gas Hydrate —a Potential New Source of Natural Gas— to Market

U.S. Department of the Interior
Minerals Management Service

Cover illustration is a photograph of gas hydrate demonstrating that the methane within the ice matrix will burn when lit. Gas hydrate consists of a mixture of methane gas trapped within a water lattice that is frozen in place. Hydrates concentrate 160 times more methane in the same space as free gas at atmospheric pressure.

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Prepared by

Minerals Management Service
Offshore Minerals Management Program

For the
U.S. Congress

U.S. Department of the Interior
Minerals Management Service **August 2006**

Preface

This report is required by Section 353 of the Energy Policy Act of 2005 (EPACT2005) entitled, "Gas Hydrate Production Incentive." Section 353(e) directs the Secretary of the Interior, in consultation with the Secretary of Energy, to submit a report to Congress not later than 365 days after the date of enactment of the Act (i.e., August 8, 2005). As directed, this report addresses further opportunities to enhance production of natural gas from gas hydrate resources on the Outer Continental Shelf and on Federal lands in Alaska through the provision of other production incentives or through technical or financial assistance.

This report was prepared by the U.S. Department of the Interior, Minerals Management Service (MMS), and is based on discussions within the Federal interagency hydrate working groups (which represent DOI bureaus—MMS, the Bureau of Land Management, and the U.S. Geological Survey; and the National Energy Technology Laboratory of the Department of Energy). It also reflects public comment on the Department of the Interior's Advanced Notice of Proposed Rulemaking (ANPR), published in the Federal Register on March 8, 2006—ANPR number 1004-AD81 (71 Fed. Reg. 11559).

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Introduction

Over the past five years, the United States has seen record prices for natural gas. Industry has responded to this price signal with significant increases in drilling activity. However, this activity has not yet produced an increase in supply. As a result, the Energy Information Administration (EIA) has raised its predictions for gas prices and gas importation, while simultaneously lowering its expectations for long-term gas use in the United States. Clearly, development of new domestic gas supply sources over the next two decades would have significant positive impacts on the nation's economy, environment, and national energy situation. Economic benefits of increased domestic supply capacity could include significant cost savings to consumers as well as preservation of gas-price-sensitive manufacturing jobs. Environmental benefits would emerge as well from the increased utilization of clean-burning natural gas. Energy security benefits would be derived from an increase in the share of the nation's energy supply that is produced domestically, and in the general expansion of gas supply options to deal more successfully with uncertain future energy supply scenarios.

Gas hydrate resources may be one of the nation's most promising energy supply sources. The potential for natural gas production from gas hydrate has been demonstrated, but significant challenges still exist with developing technologies for exploration, development, and economic extraction of these resources, both onshore and offshore. Nonetheless, the vast scale of the potential resource cannot be ignored. The U.S. Geological Survey (USGS) notes that if one percent of the expected in-place resource can be accessed, the Nation could more than double its technically recoverable natural gas resource base.

To promote natural gas production from gas hydrate resources on the Outer Continental Shelf (OCS) and Federal lands in Alaska, Congress included provisions in the Energy Policy Act of 2005 (EPACT2005) to address gas hydrate production incentives (section 353), and provide for a continued program of methane hydrate research (section 968). Section 353 of EPACT2005 provides for a program of royalty relief if the Secretary determines that such royalty relief would encourage production of natural gas from gas hydrate resources. Additionally, Section 353(e) directed the Secretary of the Interior, in consultation with the Secretary of Energy, to undertake a review and submit a report on further opportunities to promote gas hydrate development through other production incentives or technical or financial assistance. This report responds to the requirements of Section 353(e)—the following discussion summarizes our review and findings, and provides suggestions on opportunities to enhance exploration and development of gas hydrate resources which could help accelerate the arrival of gas hydrate as a viable energy resource in the United States.

First, to provide a context for this discussion, we describe the current natural gas supply situation in the United States, and briefly explain what we know about gas hydrate resources, its formation and occurrence, and possible methods of future production.

Background

Natural Gas Supply and Demand

Natural gas production in the United States was able to keep pace with consumption until the mid-1980's (figure 1). However, as demand for natural gas increased, net natural gas imports also increased—from 4 percent in the mid-1980's to more than 15 percent today. According to EIA's recent Annual Energy Outlook (AEO2006), the United States imported more than 4 trillion cubic feet (Tcf) of natural gas in 2005 and exported 0.9 Tcf, resulting in net imports of 3.1 Tcf. The nation's consumption of natural gas is projected to steadily increase, reaching over 27 Tcf by 2030. At the same time, the domestic production of natural gas from conventional sources will not be able to keep pace with this increased demand. The AEO2006 estimates that net imports will increase to 21 percent of consumption by 2030. Some earlier forecasts, such as that of the National Research Council (NRC, 2004), predicted still higher levels of demand by 2020. Most of our imported natural gas currently comes through pipelines from Canada. The importation of natural gas by pipeline from Canada has been increasing throughout the 1990's and 2000's, from 1.4 Tcf in 1990 to 3.6 Tcf in 2005 and is rapidly approaching pipeline capacity. Increased future demand for natural gas from within Canada will put further pressure on this source of supply. Liquefied natural gas (LNG), largely from Algeria and Trinidad, currently accounts for most of the remaining natural gas imports.[1]

Growing demand for natural gas, and the volatility in its price experienced in recent years, has emphasized a need to identify potential alternative sources to supply our nation's growing demand for natural gas. If this demand continues to grow as expected, unless new domestic natural gas resources are identified and enabled, the nation likely will: 1) become increasingly reliant on imports, and 2) continue to shift the source of those imports from historically secure countries (such as Canada) to a new cadre of international suppliers of unproven reliability.

[1] LNG is natural gas cooled into liquid form for transport in specially designed tanker ships. Technological advancements in recent years which have significantly reduced the cost of processing, shipping in specialized tankers, and regasifying LNG, coupled with present high prices of natural gas in the United States, have made LNG a commercially viable source to meet the nation's natural gas demands. However, only four land-based terminals capable of receiving and processing LNG with a total capacity of less than 1 Tcf per year currently exist in the continental United States. A new deepwater port, the Gulf Gateway Energy Bridge LLC, which is located in the Gulf of Mexico about 116 miles offshore Louisiana, began accepting LNG deliveries in March 2005 (but is not currently active). The Maritime Administration has issued 2 additional licenses for LNG deepwater ports (not yet constructed) and currently has about 10 applications under review. To meet the future demand for natural gas from LNG will require many more plants and terminals at a considerable expense and will increase our dependence on foreign imports. Since 1993, imports of LNG have increased 900 percent, and another 300 percent increase is anticipated by 2030 (AEO2006).

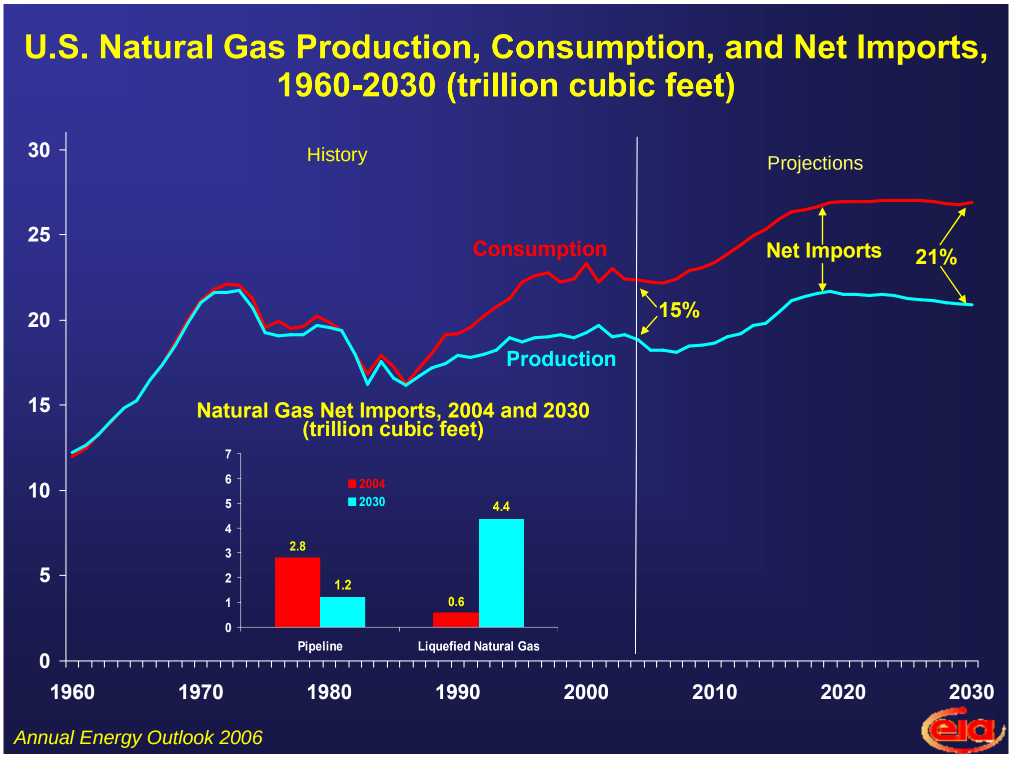

Figure 1. Production, Consumption and Net Imports of Natural Gas

Meeting the Future Supply Shortfall

EIA anticipates (AEO2006) that the future demand for natural gas will be met by a combination of events (figure 2). The base production of domestic natural gas from conventional sources is expected to decline after 2015 (figure 2). The projected shortfall after 2015 between consumption and domestic production from conventional sources is expected to be met with growth in Alaska production (which is dependent upon the completion of a gas pipeline), growth in LNG imports, and growth in unconventional production.[2] EIA projects that the importation of natural gas through pipelines will decrease by 2030 due to increasing domestic demand in Canada. It also forecasts that additional growth in LNG imports will meet much of the increased U.S. demand for natural gas. However, increasing demand for natural gas in developing countries with expanding economies may put pressure on the LNG supply, resulting in increased costs. At the same time increasing demand for oil in these countries will create an additional demand for natural gas in the form of gas-to-liquids (GTL).

[2] Unconventional resources have been variously defined, but typically include tight (or low permeability) gas sands, gas shales, and coalbed methane (CBM). The economically recoverable portions of each resource base are currently being produced in the United States and elsewhere. However, vast volumes still are not commercial. Unconventional natural gas production accounted for 40 percent of all domestic natural gas production in 2004 (AEO2006) and is steadily increasing. The latest estimates from various sources suggest that from 268 to 325 Tcf of technically recoverable gas resources remain in unconventional formations and that the economic recoverability of that resource is not very well known.

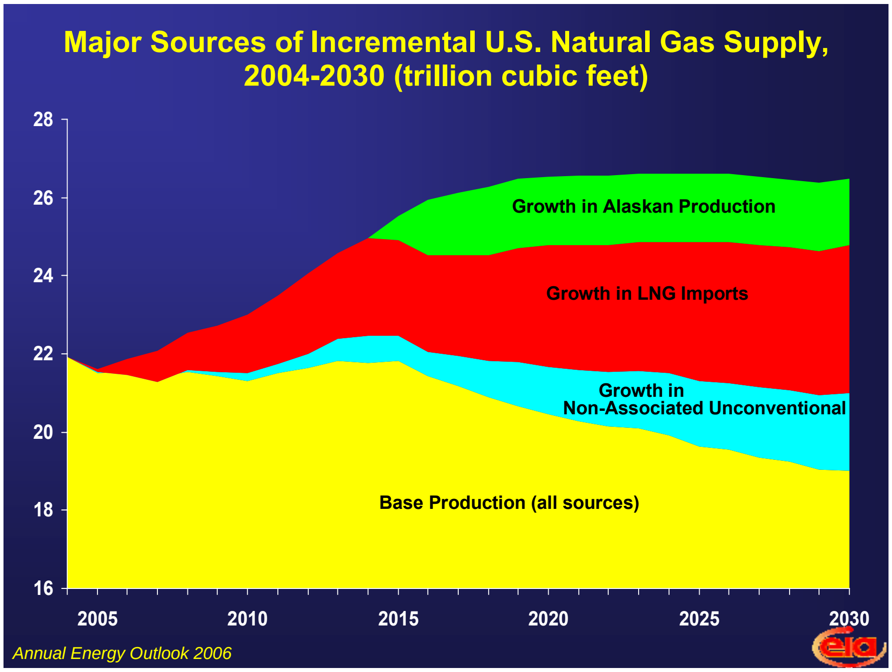

Figure 2. Natural Gas Supply by Category

Thus, even if our growing demand for natural gas can be met by increased LNG imports, our dependence on foreign sources of energy will increase, adversely affecting our balance of trade and potentially compromising national security interests. A potential alternative solution to meet our hunger for natural gas may come from production of natural gas from gas hydrate which is present in extensive amounts offshore, within our Exclusive Economic Zone (EEZ), and in the Arctic region. According to a report submitted to Congress by the NRC entitled, "Charting the Future of Methane Hydrate Research in the United States" (NRC, 2004), a shortfall in natural gas supply from conventional and unconventional sources is expected to occur in about 2020, and methane hydrate from below the permafrost in the Arctic or beneath the seafloor... may have the potential to alleviate this projected shortfall. They also stated that, "The United States and other nations recognize that given sufficient in-place reserves, there are no obvious technical or engineering roadblocks to prevent commercial production of gas from hydrate in the future." Unlike other unconventional resources which require costly and specialized production technology, it is possible that natural gas from gas hydrate could be recovered at a moderate cost if the hydrate can be produced with only minor modifications to existing exploration, drilling, and production technology.

What is Gas Hydrate?

Gas hydrates are ice like crystalline substances occurring in nature where a solid water-lattice accommodates gas molecules (primarily methane, the major component of natural gas) in a cage-like structure, also known as clathrate. The amount of natural gas in methane hydrate is estimated to be far greater than the entire world's conventional natural gas resources, so hydrates could potentially become a significant source of natural gas. One volume of hydrate constitutes about 160 times the volume of conventional natural gas. Methane hydrate burns with a clean flame when lit (see front cover).

Gas hydrate represents a potentially enormous untapped domestic energy source. The mean in-place amount of gas hydrate in the United States is currently estimated to be 200,000 Tcf (Collett, 2002). Milkov and Sassen (2001), who judge only massive surficial accumulations to be feasible production targets, estimate the gas hydrate resources of the northwestern Gulf of Mexico to be 15 times lower than the estimates of Collett (1998). Although limited production testing indicates that gas hydrate is producible (Mallik Project), and the potential amount of in-place gas hydrate is enormous, how much of that amount is technically and commercially producible is still to be determined.

Prior to the 1960's, gas hydrate was studied as an academic research interest and for its role as a nuisance in pipeline transmission of natural gas and as a safety hazard in drilling conventional oil and gas wells. In the 1960's the first suspected production from gas hydrate was reported from the Messoyakha field in western Siberia. Throughout the 1980's and in recent years, gas hydrate has become of increasing interest, particularly in countries such as Japan and India where domestic sources of natural gas are very limited. Although a significant amount of knowledge concerning the physical and chemical properties of gas hydrate and its formation and recognition criteria have been developed, numerous technical challenges remain before gas hydrate can be considered as a viable energy source.

Formation and Occurrence of Gas Hydrate

Gas hydrate forms only within a specific range of pressure and temperature conditions and when a sufficient supply of natural gas and water is present. A pressure–temperature phase diagram that shows the zone (PT-window) of pressure and temperature combinations where gas hydrate is stable is shown in figure 3 for deepwater marine sediments and Arctic onshore areas. The location and dimension of the PT-window of gas hydrate is affected by the composition of the gas, pore-water salinity and local temperature gradient. In the Gulf of Mexico particularly, the presence of large salt diapirs (intrusive structures) reduce the size of the hydrate stability zones and adds significant complexity to its shape.

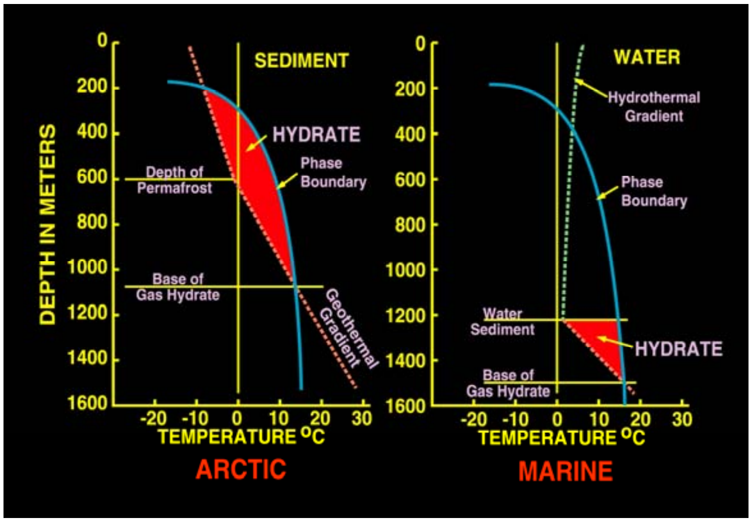

Figure 3. The Phase Diagram of Gas Hydrate in Arctic and Marine Environments, (Collett)

Note: PT-windows where gas hydrate is stable are shown in red

The formation and preservation of gas hydrate follows the same principles of conventional petroleum systems—i.e., requirements for an effective source of both methane and water, migration path, suitable reservoir rock, and seal. However, the existence and maintenance of a suitable pressure, temperature, and chemical regime for the reservoir rock becomes an additional condition. As sufficient quantities of natural gas migrate through a favorable P-T regime for gas hydrate in the presence of sufficient quantities of water and other suitable chemical conditions, gas hydrates form. Gas hydrate can occur as inclusions, or can be disseminated within the sedimentary section as pore-filling grains, cements, nodules or as laminae and veins. Hydrate-bearing sedimentary sections range in thickness from a few centimeters to several tens of centimeters to tens of meters (Collett, 2002). Although most of the marine gas hydrate occurrences are in clayey sediments with very little to no permeability having low gas hydrate concentrations, the Gulf of Mexico holds the possibility of having sand reservoirs that could have high gas hydrate saturations. A Chevron-led Joint Industry Project (JIP) is planning to test, through drilling, some of these sandy gas hydrate reservoirs by 2008. For gas hydrate to be a viable and commercially producible energy resource, sandy or fractured reservoirs with sufficient permeability need to be the target of exploration and research.

Production of Gas Hydrate

The dissociation of gas hydrate is represented by the following expression (Pooladi, 2006):

$$(CH_4 \bullet 6H_2O)_{solid} \rightarrow (CH_4)gas + 6(H_20)_{liquid}$$

The energy value of the produced gas is ten times what is needed for the dissociation of hydrate (Holder *et al.*, 1982). Depressurization, thermal stimulation, and inhibitor injection (figure 4), or a combination of these methods, have been considered as possible methods of production for gas hydrate. Recent production testing in the Mallik project in Canada utilized a combination of depressurization and thermal stimulation. Depressurization has been judged to be the most economic method (Sloan, 1998), and this is reinforced by the production testing of the Mallik project (Dallimore and Collett, 2005). Collett (2002) points out that the extraction of gas by depressurization may suffer from the formation of ice or reformation of gas hydrate due to the endothermic property of gas hydrate dissociation. McGrail *et al.* (2004) suggested and validated in the laboratory the injection of CO_2 as a means to destabilize the hydrate equilibrium and as a possible method to produce gas hydrate. The method of CO_2 injection also potentially provides additional benefits of CO_2 sequestration and sediment stability maintenance.

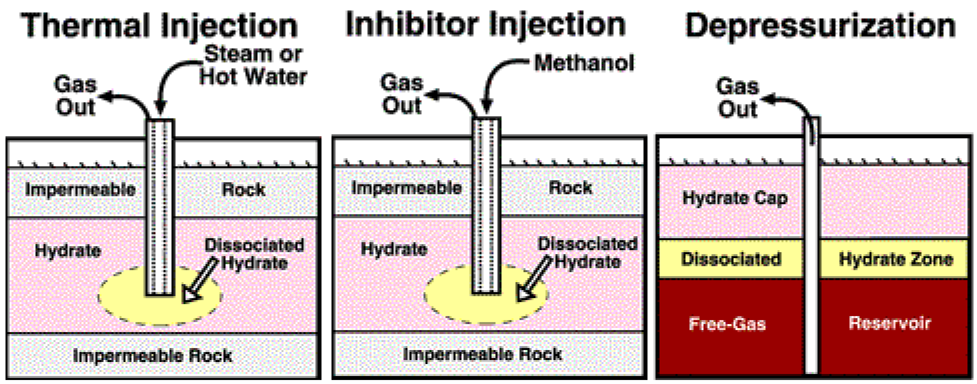

Figure 4. Possible Gas Hydrate Production Methods (Collett, 2002)

Our state-of-the-art knowledge on gas hydrate production from natural reservoirs comes primarily from laboratory studies and modeling using numerical simulators. However, these simulations and modeling efforts utilized real data from the field or production test data such as that obtained from the Mallik production test. The Mallik project provided an initial limited scientific experiment that showed promise but left many questions that can only be answered by a series of long-term production tests in a variety of settings. Knowledge gathered from these studies about the thermodynamics and the kinetics of formation and dissociation of methane hydrate will influence production strategies. The influence of sediment properties on the behavior of hydrate dissociation and resultant water and gas flow through the changing reservoir needs to be established for application of large-scale simulators to evaluate production capabilities (Moridis *et al.*, 2006). The biggest need, therefore, is for a controlled and extended production test from a natural hydrate accumulation to provide a meaningful dataset to calibrate and validate the emerging models.

Opportunities to Enhance Production of Natural Gas from Gas Hydrate Resources—Production Incentives and Technical and Financial Assistance

Any future commercial development of gas hydrate resources by industry on Federal lands could only occur under a mineral lease issued by the Department of the Interior—i.e., by the Minerals Management Service for resources on the OCS or the BLM for onshore resources. These bureaus are responsible for developing regulatory guidelines and programs for addressing the recovery of gas hydrate, therefore, the DOI is actively participating in collaborative research and development programs, and developing models to evaluate potential resources on Federal lands. Early involvement will ensure that DOI has the necessary information to prepare environmental assessments, conduct resource evaluations, and identify any safety concerns. Some of the environmental issues that need to be addressed include the effects of methane hydrate on: 1) seafloor stability in the presence of petroleum drilling and production, and 2) surface or near-surface biological communities.

Section 353 of EPACT2005 directs the Secretary of the Interior to determine if rulemaking is needed to provide royalty relief for gas hydrate (up to 30 billion cubic feet per eligible lease) and identify other opportunities to enhance gas hydrate production through production incentives or technical and financial assistance.

Providing incentives or technical and financial assistance for energy mineral resource development are tools that the government can use to share risks with private industry and attract capital for investment in gas hydrate technology development and stimulate industry interest in exploration and development of this new, alternative energy source. Without some form of government assistance, the huge resource of gas hydrates may never be realized, or at the very least may be delayed for decades. Determining the appropriate form of such assistance will depend on the stage of technology development and knowledge about feasible methods of finding and extracting the gas from specific locations.

Though the resource base is potentially huge, there is currently great uncertainty about the quantity of hydrate that may be commercially extracted. It is important to recognize that methane hydrate science is still relatively new. Demonstrating the energy resource potential of gas hydrate will pose significant technical challenges. If current obstacles can be overcome, natural gas from hydrate could become an abundant domestic source of energy for the future. The commencement of such production could be at least a decade from now—the DOE's strategy for the Methane Hydrate R&D Program Interagency Roadmap states a goal of 2015 to demonstrate arctic production technology and 2025 for offshore production technology for gas hydrate.

In March 2006, the DOI requested public comment to assist in preparation of possible rulemaking for a gas hydrate production incentive in the form of royalty relief for eligible leases (under Section 353(b) of EPACT2005). Most of the comments received on the Advanced Notice of Proposed Rulemaking (ANPR)—a total of 6 commenters—focused on support for continued governmental and cooperative research for work on resource characterization/behavior, environmental and safety studies, and technology development and testing. Two of the industry commenters also supported royalty relief or tax incentives to help mitigate the risks of investing in this new energy resource and encourage exploration.

Production Incentives

The U.S. Commission on Ocean Policy, in its September 20, 2004 report, "An Ocean Blueprint for the 21st Century," stated that there is still no known practical and safe way to develop gas hydrate and it is clear that much more information is needed to determine whether significant technical obstacles can be overcome to enable methane hydrate to become a commercially viable and environmentally acceptable source of energy.

Before commercial extraction can go forward, more reliable means of identifying the location and composition of gas hydrate is needed. Advanced seismic and/or other remote-imaging technologies will be needed to identify the most promising areas of high hydrate concentration and provide for prospect delineation. The logistical difficulties of conducting basic field R&D in the remote Arctic and deepwater environments, combined with a lack of current allocation of industry resources for such research, means that the feasibility of near-term commercial methane production from hydrate has not yet been established. Modifications to existing technology or new extraction methods and processes need to be developed.

Production incentives, such as tax credits or royalty relief to improve project economics, are not likely to be effective in promoting near-term exploration and development of gas hydrate prospects until the feasibility of hydrate production is clearly demonstrated in a rigorous field (R&D) program. Financial incentives, like reductions in the production royalty requirement in a lease, which is prospect-specific and helps reduce project risk, can be more effective and cost-efficient once commercial development becomes closer to reality. Without an understanding of exploration and development technologies that would be employed, production and timing characteristics, and the plans and cost information from actual proposed projects, designing an appropriate incentives program that would be needed in a given market environment to encourage gas hydrate production would be problematic.

Private industry generally has yet to vigorously pursue research that could make gas hydrate development viable. Although currently high gas prices may encourage increased interest in gas hydrate, they may also serve to actually delay the rate of investment in long-term research and development ventures for unconventional resources, like gas hydrate on the OCS or in Alaska, in favor of added investments in alternative conventional sources of natural gas or increased investments in infrastructure for the importation of LNG. Consequently, it is unclear what amount of production incentive, if any, at this very early stage of gas hydrate development would be sufficient to cause industry to shift significant resources to the development of gas hydrate resources; or even if it would be appropriate or desirable to encourage such a shift by providing financial incentives at this early stage.

Given the current need for research and development to demonstrate the production capability and commerciality of gas hydrate, the early stages of industry exploration activity, and industry's ongoing investment in other sources of natural gas supplies, it likely would be premature to consider production incentives for gas hydrate development. Before gas hydrate can be produced commercially, our basic understanding of how to locate, characterize and drill for this resource in a safe and environmentally acceptable manner must be greatly enhanced through additional research and testing.

Technical and Financial Assistance

The only testing on gas hydrate to date has been done with the help of government funding. Until recently, most of the oil and gas industry's interest in hydrate focused on hazard prevention. But, with growing international interest in gas hydrate as a potential energy source, some industry groups have become active participants in cooperative research with the Government and academia to develop appropriate technology for the future exploration and production of hydrate resources.

Federal technical and financial assistance that will help advance the future commercial production of gas hydrate is part of a well established program managed by DOE and its National Energy Technology Laboratory. The Methane Hydrate Research and Development Act of 2000 provided direction for hydrate research, with planned research framed under the National Methane Hydrate R&D Program through discussions among the six participating Federal agencies (DOE, USGS, MMS, NOAA, the Naval Research Lab, and the National Science Foundation) and in consultation with advisory panels from industry and academia. The EPACT2005, section 968, extended this program and authorized funding of $155 million over the next five years. The program is designed to foster cooperation between federal agencies, industry, research institutions, and universities—research is carried out through grants, contracts, or cooperative agreements with a competitive, merit-based process to conduct basic and applied research, assist in developing technology, and/or conduct test drilling. Examples of cooperative research for gas hydrate to date includes the Gulf of Mexico Joint Industry Project led by Chevron, a government-industry cost-shared collaborative 4-year project to characterize the naturally occurring gas hydrate in target areas in the Gulf of Mexico, and the Alaskan Hydrate Project, a 3-year cost-shared cooperative agreement between the DOE, Anadarko Petroleum Corp., Maurer Technology Inc., and Noble Engineering and Development which planned, designed and implemented a program to safely and economically drill and produce gas from hydrate in Arctic fields in Alaska. However, no gas hydrate was found in this project.

Over the past 5 years, unprecedented progress has been made in methane hydrate R&D, resulting in significant advances in understanding of hydrate, its role in nature, and its potential as a future energy resource. However, much work is still needed to develop advances in technology that will provide better information on the distribution and concentration of hydrates. Work conducted for the Mallik 2002 gas hydrate production research well program showed that hydrate production is technically feasible under certain conditions, but further long-term production testing is needed to determine its potential for extraction in other conditions at viable rates and its commercial recoverability. Although extensive work is in progress for gas hydrate production simulation through reservoir simulation, and numerous models are available, more modeling work, along with field verification, is needed before gas hydrate is ready for prime time production.

As noted above, the comments received on DOI's ANPR for gas hydrate production incentives strongly supported a continued government role in research and technology development, and acknowledged the importance of industry cooperation in research that ultimately could bring gas hydrate to production. BP Exploration (Alaska) Inc. (BPXA), in a project funded by DOE, recently approved an Arctic stratigraphic test well dedicated to improving the understanding of gas hydrate reservoirs is supportive of future cooperative research projects. Chevron supported incentives to stimulate industry investment in research to develop appropriate gas hydrate technologies required to overcome the technological challenges for the commercial production of gas hydrate resources. Hydrate Energy International noted that although recent advances make it technically possible to produce gas from gas hydrate reservoirs, additional production tests are needed.

Based on a review of the current research and emerging technologies for gas hydrate development, it appears that continued cooperative projects and grants focused on research and new technology development for the location, characterization, and extraction of hydrate in the Arctic and marine environments would provide the best opportunities to encourage future production of natural gas from gas hydrates.

Recently (July 2006), the Technical Coordination Team (TCT) of the National Methane Hydrate R&D Program completed a report detailing the need for further studies for gas hydrates. The report entitled, “An Interagency Roadmap for Methane Hydrate Research and Development,” is attached as an appendix. The TCT report outlines a plan of action to fully address the goals of the Methane Hydrate Research and Development Act of 2000, as amended by section 968 of the EPACT2005. The report presents two roadmaps to determine and realize hydrate’s energy supply potential—one for the Arctic and another for the marine gas hydrate. It also stressed the need for studying the environmental impacts of gas hydrate and detailed a roadmap for research and environmental studies. This roadmap is consistent with the governmental role of supporting research and development in fields with great potential public value that are too high-risk, high-cost, and long-term to be conducted by the private sector alone.

The roadmap provided in the TCT report stresses the need for confirmation of the extent and nature of marine gas hydrate resources and development of technology to produce them. It recommends a two-pronged approach: learning from easily accessible, already identified gas hydrate occurrences in the Arctic, and modifying and applying the technology of production for the marine environment, in particular in the Gulf of Mexico. In the short term, the following actions need to be pursued:

- In the Arctic
    - Research on the demonstration of technologies for gas hydrate prospect delineation and drilling.
    - Series of extended well production tests utilizing alternative production, stimulation, and well design concepts across a range of relevant geologic and reservoir conditions.
    - Analysis of production tests and complementary laboratory and modeling work to assess economic feasibility of production.

- In the marine environment (Gulf of Mexico)
    - Research on and demonstration of technologies for marine gas hydrate prospect delineation and drilling.
    - Extensive well drilling to ground truth developing marine exploration technologies and document the scale and distribution of marine resources.
    - Identification of suitable locations for marine hydrate production tests.

Possible timeframes for gas hydrate development in the Arctic and the marine environments from the TCT report are presented below. The report recommends that both of these proceed together with the environmental roadmap.

Marine Gas Hydrate Production Roadmap

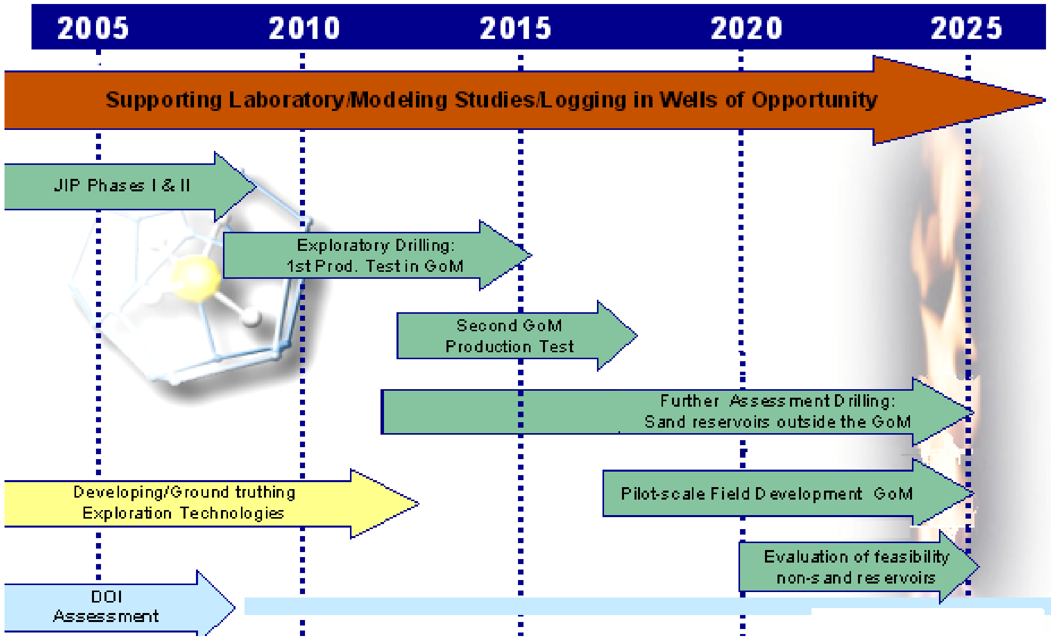

Figure 5. DOE Roadmap for Marine Gas Hydrate Production
Source: An Interagency Roadmap for Methane Hydrate Research and Development, Report of the Interagency Technical Coordination Committee (TCT), July 2006

Arctic Gas hydrate Production Roadmap

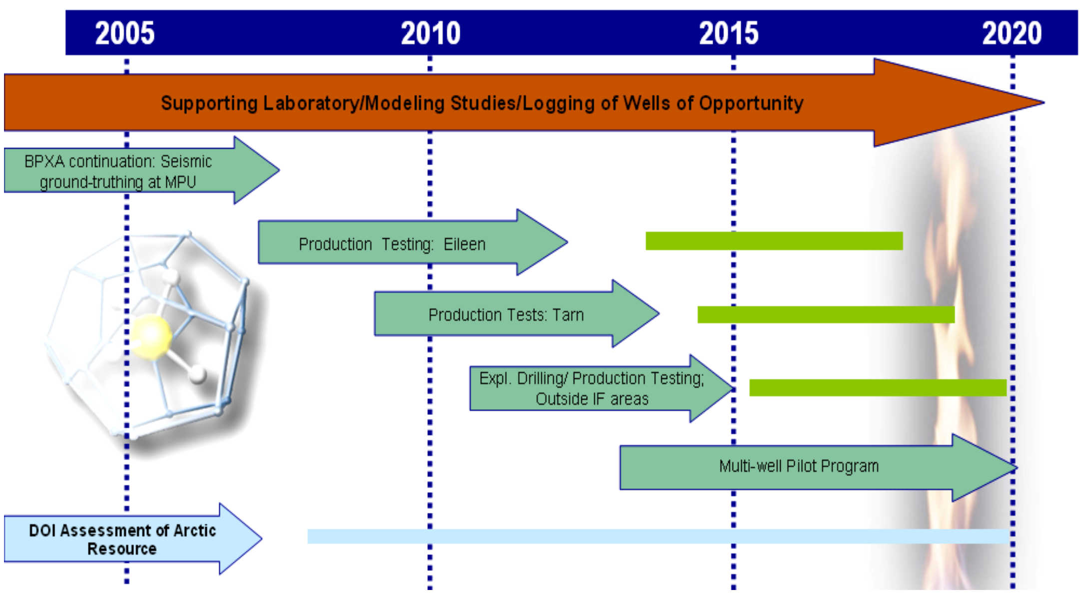

Figure 6. DOE Roadmap for Arctic Gas Hydrate Production
Source: An Interagency Roadmap for Methane Hydrate Research and Development, Report of the Interagency Technical Coordination Committee (TCT), July 2006

Summary and Recommendations

Given the current lack of information about gas hydrate production potential, the ongoing preliminary research in progress, the absence of industry exploration activity, and the already high market price for gas, we do not recommend specific government production incentives for gas hydrate at this time. Production incentives, like royalty relief, would be better-suited for encouraging prospect-specific exploration and development of gas hydrate resources if needed once necessary technology is developed and commercial recoverability is established. At this stage of gas hydrate development, Federal incentives—through technical and financial assistance for research and development programs, database development, education and training, and assistance and collaboration in field testing of production methods—would be the most effective way to help accelerate the process of commercial production of gas hydrate resources. Assistance should be provided for R&D that is broad-based and addresses the entire spectrum of resource identification and exploitation activities. In particular, Federal assistance is needed for the continued support of public-private partnerships in both field and laboratory research programs; most notably new drilling and production testing, as well as data collection in "wells of opportunity"—i.e., providing access for data collection in the shallow sections of wells with deeper, conventional, targets.

The Federal government now provides such technical and financial assistance primarily under the National Methane Hydrate R&D Program, with funding from DOE and other participating agencies (i.e., USGS, the Naval Research Laboratory, MMS, NOAA, and the National Science Foundation). Research needs are identified and/or planned through discussions and collaboration among the participating 6 Federal agencies and in consultation with advisory panels from industry and academia. Under this DOE-led program, grants, contracts or cost-shared funding for cooperative agreements, as well as initiatives from other agencies, are used to direct specific basic and applied research projects on the energy potential, safety and environmental aspects of methane hydrate exploration and development. Detailed information about the program, including links to information about interagency coordination, R&D planning and gas hydrate projects, can be found on DOE's web page at:

http://www.netl.doe.gov/technologies/oil-gas/FutureSupply/MethaneHydrates/maincontent.htm#MoreText

The above-mentioned "roadmaps" prepared by DOE and an interagency technical coordination team will be used to help determine priorities and funding levels for near-term and future Federal technical and financial assistance. Through a competitive, merit-based process, using solicitation of proposals for needed research, the Government will direct its financial assistance to projects which provide the best opportunities to encourage gas hydrate production.

The program currently envisions continued industry collaboration and joint industry projects to ensure vigorous and accelerated research and technology development in the following areas:

1) Development and ground-truthing of reliable remote sensing technologies that will enable accurate detection and characterization of hydrate accumulations in both the Arctic and marine environments;

2) A coordinated program of extended production tests that is fully integrated with controlled investigation of critical reservoir parameters in the laboratory and continuous development and validation of production simulators; and

3) Studies of the impact of potential hydrate production technologies on the natural environment, including the potential for, and impacts of, induced sediment instability and methane release to the atmosphere.

The Federal government should continue to support, encourage, and participate in industry alliances, such as Chevron's Gulf of Mexico JIP for exploration and production testing. Adequate funding is critical for the DOI Bureaus (BLM, MMS, and USGS) to conduct or encourage and financially support research by academic institutions and national laboratories in resource characterization, modeling and reservoir simulation. DOE will need continued funding to support technology development through support of research by academic and national laboratories.

Chevron U.S.A, Inc. has aptly pointed out in their response to the ANPR:

> "History has shown us that when large accumulations of hydrocarbon resources are found in frontier areas (e.g. North Slope of Alaska), technology will be developed to produce those resources. It is normally just a matter of time and money."

References

AEO 2006. Energy Information Administration, U.S. Department of Energy. February 2006. Annual Energy Outlook 2006, DOE/EIA-0383(2006).

Collett, T.S. 1998. Well Log Evaluation of Gas Hydrate Saturations: Society of Petrophysicists and Well Log Analysts Transactions, 39th Annual Symposium.

Collett, T.S. 2002. Energy Resource Potential of Natural Gas Hydrates: American Association of Petroleum Geologists Bulletin, V. 86.

Dallimore, S.R., and T.S. Collett (Eds.). 2005. Scientific Results from the Mallik 2002 Gas Hydrate Production Research Well Program, Mackenzie Delta, Northwest Territories, Canada: Bulletin 585—Geological Survey of Canada.

Holder G.D., et al. 1982. A Thermodynamic Evaluation of Thermal Recovery of Gas from Hydrates in the Earth: Society of Petroleum Engineers, SPE 8929.

McGrail, B. P., T. Zhu, R. B. Hunter, M.D. White, S.L. Patil, and A.S. Kulkarni. 2004. A New Method for Enhanced Production of Gas Hydrates with CO_2: AAPG Hedberg Conference, Abstract.

Milkov, A. V. and R. Sassen. 2001. Estimate of Gas Hydrate Resource, Northwestern Gulf of Mexico Continental Slope: Marine Geology, V. 179.

Moridis, G.J., Y. Seol, and T.J. Kneafsey. 2006. Studies of Reaction Kinetics of Methane Hydrate Dissociation in Porous Media: Topical Report, Lawrence-Berkley National Laboratory Press.

National Research Council. 2004. Charting the Future of Methane Hydrate Research in the United States: The National Academies Press.

Pooladi-Darvish, M. 2006. Gas Production from Hydrate Reservoirs and its Modeling: Society of Petroleum Engineers, SPE 86827.

Sloan, E.D., Jr. 1998. Clathrate Hydrates of Natural Gases: Marcel Dekker, Inc.

Technical Coordination Committee (TCT). 2006. An Interagency Roadmap for Methane Hydrate Research and Development, U.S. Department of Energy, Office of Fossil Energy, Prepared by: The Technical Coordination Team of the National Methane Hydrate R&D Program.

U.S. Commission on Ocean Policy. An Ocean Blueprint for the 21st Century, Final Report. Washington, DC, 2004. ISBN#0–9759462–0–X.

Appendix

An Interagency Roadmap for Methane Hydrate Research and Development

U.S. DEPARTMENT OF THE INTERIOR
MINERAL REVENUES
OFFSHORE MINERALS
STEWARDSHIP
MINERALS MANAGEMENT SERVICE